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Epitome

(57) [Abstract]

[Objects of the Invention] The pitting-proof nature of the high intensity aluminum alloy tubing material for aluminum heat exchangers is raised.

[Elements of the Invention] By weight % which constitutes the high intensity aluminum alloy tubing material for aluminum heat exchangers, Fe:0.2-1.5%, Contain Si:0.05-1.2% and the need is accepted further. Zr: 0.05-0.15%, Mn:0.1-1.2%, Ti:0.02-0.2%, Mg:0.05-0.3% and ** -- one sort or two sorts or more being contained, and at a rate of occupying at the whole into aluminum alloy which has the presentation which the remainder becomes from aluminum and an unescapable impurity Zn: 0.05-0.5%, one sort in Ga, Cd, In, Sn, Tl, and Pb, or : [two or more sorts of] 1-100 ppm It is made to contain as an alloy content.

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CLAIMS

[Claim(s)]

[Claim 1] The high intensity aluminum alloy tubing material for aluminum heat exchangers excellent in the pitting-proof nature characterized by constituting from an aluminum alloy characterized by providing the following At weight %, it is Fe:0.2–1.5%. Si:0.05–1.2% is contained and it is Zn:0.05–0.5% further. One sort in Ga, Cd, In, Sn, Tl, and Pb, or : [two or more sorts of] 1–100 ppm Presentation which it contains and the remainder becomes from aluminum and an unescapable impurity

[Claim 2] The high intensity aluminum alloy tubing material for aluminum heat exchangers excellent in the pitting-proof nature characterized by constituting from an aluminum alloy characterized by providing the following weight % -- Fe:0.2–1.5% Si:0.05–1.2% -- containing -- Zr: -- 0.05 – 0.15%, Mn:0.1–1.2%, Ti:0.02–0.2%, and ** -- one sort or two sorts or more -- containing -- further -- Zn:0.05–0.5% One sort in Ga, Cd, In, Sn, Tl, and Pb, or : [two or more sorts of] 1–100 ppm Presentation which it contains and the remainder becomes from aluminum and an unescapable impurity

[Claim 3] The high intensity aluminum alloy tubing material for aluminum heat exchangers excellent in the pitting-proof nature characterized by constituting from an aluminum alloy characterized by providing the following At weight %, it is Fe:0.2–1.5%. Si:0.05–1.2% is contained, Mg:0.05–0.3% is contained, and it is Zn:0.05–0.5% further. One sort in Ga, Cd, In, Sn, Tl, and Pb, or : [two or more sorts of] 1–100 ppm Presentation which it contains and the remainder becomes from aluminum and an unescapable impurity

[Claim 4] The high intensity aluminum alloy tubing material for aluminum heat exchangers excellent in the pitting-proof nature characterized by constituting from an aluminum alloy characterized by providing the following weight % -- Fe:0.2–1.5% Si:0.05–1.2% -- containing -- Zr: -- 0.05 – 0.15%, Mn:0.1–1.2%, Ti:0.02–0.2%, and ** -- one sort or two sorts or more Mg: Contain 0.05–0.3% and it is Zn:0.05–0.5% further. One sort in Ga, Cd, In, Sn, Tl, and Pb, or : [two or more sorts of] 1–100 ppm Presentation which it contains and the remainder becomes from aluminum and an unescapable impurity (above weight %)

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Industrial Application] This invention relates to the high intensity aluminum alloy tubing material which demonstrates the outstanding pitting-proof nature, when it uses for the soldering assembly of aluminum heat exchanger as a tubing material.

[0002]

[Description of the Prior Art] It is manufactured by carrying out assembly soldering of the aluminum alloy fin material which carried out the clad of the aluminum alloy wax material to radiators, such as the former, for example, an automobile, and a motorcycle, aluminum alloy tubing material to which aluminum heat exchangers, such as an evaporator, carried out the clad of the aluminum alloy wax material to the lateral surface further, aluminum alloy fin material or aluminum alloy tubing material, one side, or both sides, and is (% shows weight % below) at weight % as the above-mentioned aluminum alloy wax material, Si:7-12% -- containing -- further -- the need -- responding -- Mg:0.1-2% Bi:0.02-0.2% and ** -- one sort or two sorts are contained and it is also known that aluminum alloy which has the presentation which the remainder becomes from aluminum and an unescapable impurity will be used.

[0003] Moreover, Fe:0.6-1.0% as it is indicated by the aluminum alloy 8011 which has the high intensity in which thinning is possible, for example, ASTM, in order to correspond to high-performance-izing of aluminum heat exchanger in recent years, a miniaturization, and lightweight-ization Si:0.5-0.9% is contained and it is also known that the high intensity aluminum alloy which has the presentation which the remainder becomes from aluminum and an unescapable impurity is used as a tubing material.

[0004]

[Problem(s) to be Solved by the Invention] However, although heat deformation is hardly carried out at the time of soldering even if it carries out thinning since aluminum alloy which constitutes this has high

intensity, especially high temperature strength in the above-mentioned conventional high intensity aluminum alloy tubing material, it is easy to generate pitting in quality of the material, and develops even into a through tube conjointly with it being thin meat, and there is a problem of resulting in a use life comparatively for a short time.

[0005]

[Means for Solving the Problem] Then, while this invention person etc. has the high intensity in which thinning is possible from the above viewpoints As a result of inquiring paying attention to the above-mentioned conventional high intensity aluminum alloy tubing material, into aluminum alloy which constitutes a high intensity aluminum alloy tubing material conventionally [above-mentioned] that aluminum alloy tubing material possessing the outstanding pitting-proof nature should be developed with Zn little as an alloy content If coexistence content of one sort in Ga, Cd, In, Sn, Tl, and Pb of a minute amount or the two sorts or more is carried out Carry out spreading diffusion of these alloy contents to the inside surface part and the lateral-surface section of a tubing material at the time of the soldering assembly of aluminum heat exchanger, and it comes to condense them. And this agglutination is promoted much more by existence of Zn, and the inside surface part and the lateral-surface section of a tubing material which said alloy content condensed in this way become ** remarkably electrochemically. Since corrosion becomes a general corrosion mold, generating of pitting comes to be controlled remarkably. On the other hand, the interior of a tubing material Since these alloy contents are in the condition of hardly existing, by the spreading diffusion to the inside surface part and the lateral-surface section of the above-mentioned alloy content The tubing material itself obtained the research result of holding high intensity equivalent to the above-mentioned conventional high intensity aluminum alloy tubing material, especially the outstanding high temperature strength of being hard to carry out heat deformation at the time of soldering.

[0006] This invention has the description in the high intensity aluminum alloy tubing material for aluminum heat exchangers excellent in the pitting-proof nature which it comes to constitute from an aluminum alloy characterized by providing the following. It is made based on the above-mentioned research result, and is Fe:0.2-1.5%. Si:0.05-1.2% is contained and it is Zn:0.05-0.5%. one sort in Ga, Cd, In, Sn, Tl, and Pb, or : [two or more sorts of] 1-100 ppm containing -- further -- the need -- responding -- Zr: -- 0.05 - 0.15%, Mn:0.1-1.2%, and Ti:0.02-0.2% Mg:0.05-

0.3% and ** -- presentation which one sort or two sorts or more are contained, and the remainder becomes from aluminum and an unescapable impurity

[0007] The reason which limited next the presentation of aluminum alloy which constitutes this in the high intensity aluminum alloy tubing material of this invention as above-mentioned is explained.

[0008] (a) Fe and Si, although the component of these has the operation which forms various kinds of compounds which combine with aluminum and are distributed to detailed homogeneity in a base, with raises high temperature strength (heat-resistant deformans) If desired high temperature strength cannot be secured even if it is less than [Si:0.05%] but the content, on the other hand, exceeds Fe:1.5% and Si:1.2%, respectively even if the content is less than [Fe:0.2%] Since the dissolution rate to the base of these components increased and corrosion resistance and workability came to have fallen as a result, that content was determined as Fe:0.2–1.5% and Si:0.05–1.2%.

[0009] (b) Ga, Cd, In, Sn, Tl, and Pb -- for these components The engine performance which carries out [the engine performance] spreading diffusion to the inside surface part and the lateral-surface section of a tubing material, and is condensed at the time of soldering as above-mentioned occurs. Although there is an operation to which generating of pitting becomes that there is nothing since the inside surface part and the lateral-surface section of a tubing material serve as ** remarkably relatively electrochemically by this and the forms of corrosion of the inside surface part of a tubing material and the lateral-surface section serve as a general corrosion mold as a result The content is 1 ppm. The effectiveness of a request to said operation is not acquired in the following, but, on the other hand, the content is 100 ppm. If it exceeds It is 1–100 ppm about the content since it becomes difficult to secure the high temperature strength which came to remain inside the tubing material and was excellent in the request after soldering. It set.

[0010] (c) Although it has the operation carries out spreading diffusion also of the self to the inside surface part and the lateral-surface section of a tubing material together with these components, and it raises the pitting-proof nature of a tubing material while promoting condensation of Ga, Cd, In, Sn, Tl, and Pb component for a ZnZn component as above-mentioned The effectiveness of a request [at less than 0.05%] of the content to said operation was not acquired, but since general corrosion came to have advanced rapidly when the content exceeded 0.5% on the other hand, the content was determined as 0.05 – 0.5%.

[0011] (d) Zr, Mn, and Ti -- for the component of these Since there is an operation which raises much more the high temperature strength which forms various kinds of compounds and is made not to carry out heat deformation at the time of soldering, and room temperature reinforcement Although contained if needed, the content, respectively Less than [Zr:0.05%], If the improvement effectiveness of a request to said operation is not acquired less than [Mn:0.1%] and less than [Ti:0.02%] but the content, on the other hand, exceeds Zr:0.15%, Mn:1.2%, and Ti:0.2%, respectively Since the compound formed came to make it big and rough and rolling workability fell, the content was determined as Zr:0.05–0.15%, Mn:0.1–1.2%, and Ti:0.02–0.2%, respectively.

[0012] (e) Since the MgMg component had the operation which dissolves on a base and raises room temperature reinforcement much more and high temperature strength came to have fallen when the improvement effectiveness in room temperature on the strength of a request of the content at less than 0.05% was not acquired but the content exceeded 0.3% on the other hand, although contained if needed, the content was determined as 0.05 – 0.3%.

[0013] Below, an example explains concretely the high intensity aluminum alloy tubing material of this invention. aluminum alloy with the component presentation shown in Tables 1–3 by the usual solution process, respectively is ingoted. Below all on condition that usual It casts in slab with the dimension of 400mm. width-of-face: -- 1450mmx die-length: -- 2800mmx thickness: -- Thickness after homogenizing in this slab : It hot-rolls to a 9mm hot-rolling plate. For subsequently, the purpose which repeats and performs cold rolling (the rate of the last cold rolling: 30%), considers as a thickness:0.2mm cold-rolled plate, adding intermediate annealing, and evaluates high temperature strength from this cold-rolled plate width-of-face: -- 30mmx die-length:, while starting the piece for suspension-proof sex test with the dimension of 140mm of a trial this invention high intensity aluminum alloy tubing materials 1–19 which are outside dimensions and consist of a width-of-face:15mmx thickness:3mm flat-like welded tube, and the comparison high intensity aluminum alloy tubing materials 1–9 which have the presentation which does not contain Ga, Cd, In, Sn, Tl, and Pb in Zn list of the constituents were manufactured, respectively.

[0014]

[Table 1]

種 別	成 分 組 成 (重量%)														
	Fe	Si	Zr	Mn	Ti	Mg	Zn	微量合金成分 (ppm)						Al+ 不純物	
								Ga	Cd	In	Sn	Tl	Pb		
本 発 明 高 強 度 Al 合 金 管 材	1	0.22	0.74	-	-	-	-	0.26	30	-	-	-	-	-	残
	2	0.83	0.60	-	-	-	-	0.33	-	60	-	-	-	-	残
	3	1.47	0.53	-	-	-	-	0.46	-	-	2	-	-	-	残
	4	0.94	0.053	-	-	-	-	0.16	-	-	-	8	-	3	残
	5	0.41	1.18	-	-	-	-	0.05	-	25	-	-	13	-	残
	6	1.16	0.64	-	-	-	-	0.20	1	-	6	-	-	4	残
	7	0.54	0.83	-	-	-	-	0.26	-	20	-	15	13	-	残
	8	0.86	0.96	-	-	-	-	0.13	10	11	10	10	20	5	残
	9	0.84	0.64	0.05	-	-	-	0.26	1	-	-	-	-	-	残
	10	0.82	0.60	-	0.63	-	-	0.23	-	50	50	-	-	-	残
	11	0.80	0.62	-	-	0.06	-	0.30	20	-	-	15	15	-	残
	12	0.86	0.66	0.13	0.21	-	-	0.41	-	-	-	-	80	-	残
	13	0.83	0.64	0.07	-	0.03	-	0.05	-	5	-	-	-	40	残
	14	0.82	0.63	-	0.16	0.15	-	0.10	-	10	20	-	7	-	残

[0015]
[Table 2]

種 別	成 分 組 成 (重量%)														
	Fe	Si	Zr	Mn	Ti	Mg	Zn	微量合金成分 (ppm)						Al+ 不溶物	
								Ga	Cd	In	Sn	Tl	Pb		
本發明 高強度 Al合 金管材	15	0.82	0.59	0.06	0.21	0.04	-	0.24	100	-	-	-	-	殘	
	16	0.80	0.63	-	-	-	0.16	0.06	-	30	-	-	20	-	殘
	17	0.79	0.62	-	0.68	-	0.19	0.09	-	-	-	-	65	-	殘
	18	0.83	0.60	0.08	-	0.03	0.05	0.23	-	-	-	40	6	10	殘
	19	0.81	0.61	0.11	0.74	0.07	0.03	0.49	12	13	-	18	-	20	殘
比 較 高強度 Al合 金管材	1	0.82	0.58	-	-	-	-	-	-	-	-	-	-	-	殘
	2	0.80	0.62	-	0.66	-	-	-	-	-	-	-	-	-	殘
	3	0.82	0.63	-	-	0.06	-	-	-	-	-	-	-	-	殘
	4	0.81	0.60	0.17	0.21	-	-	-	-	-	-	-	-	-	殘
	5	0.80	0.61	0.06	0.23	0.03	-	-	-	-	-	-	-	-	殘
	6	0.78	0.62	-	-	-	0.13	-	-	-	-	-	-	-	殘
	7	0.79	0.61	-	0.71	-	0.17	-	-	-	-	-	-	-	殘
	8	0.81	0.57	0.08	-	0.03	0.06	-	-	-	-	-	-	-	殘
	9	0.83	0.59	0.11	0.73	0.09	0.03	-	-	-	-	-	-	-	殘

[0016] In addition, inside of the conditions which are in the condition which the suspension [-proof] sex test carried out level maintenance of the 30mm of the die-length directions of the above-mentioned piece of a trial, and projected die length of 110mm horizontally, and are equivalent to vacuum soldering, i.e., the vacuum of about ten to 4 torr, temperature: It carried out to 600 degrees C on condition that maintenance for 5 minutes, and the suspension height of the protrusion point of the piece of a trial after a trial was measured.

[0017] moreover, about the above-mentioned this invention high intensity aluminum alloy tubing materials 1-19 and the comparison high

intensity aluminum alloy tubing materials 1-9 Inside of the conditions which are equivalent to vacuum soldering as well as this, i.e., the vacuum of about ten to 4 torr, temperature : in the condition of having heat-treated on condition that maintenance for 5 minutes at 600 degrees C (a) It is 1 ppm about Cu²⁺ ion. Contain and in the tap water whose temperature is 40 degrees C The tap water immersion test of the immersion during 30 days, (b) Cl - Ion : [100 ppm and SO₄ 2- ion:100ppm,] HCO₃ - Ion: 100 ppm and Cu²⁺ ion:1ppm 40cm² [in / it contains, and the water-solution immersion test of immersion is performed for 30 days into the water solution whose temperature is 40 degrees C, and / an inside] The number of pitting and the maximum pitting depth of a hit were measured. These results were shown in Tables 3 and 4.

[0018]

[Table 3]

種 別		垂下高さ (mm)	水道水浸漬試験		水溶液浸漬試験	
			孔食数 (個)	最大孔 食 深 さ (mm)	孔食数 (個)	最大孔 食 深 さ (mm)
本 発 明 高 強 度 A 1 合 金 管 材	1	10	2	0.02	5	0.01
	2	5	2	0.02	4	0.01
	3	5	3	0.02	7	0.01
	4	6	4	0.02	8	0.01
	5	7	4	0.02	9	0.01
	6	5	2	0.01	4	0.01
	7	6	2	0.02	4	0.01
	8	6	3	0.01	6	0.01
	9	5	2	0.02	4	0.01
	10	4	2	0.01	4	0.01
	11	5	2	0.02	5	0.01
	12	4	3	0.02	6	0.01
	13	5	3	0.02	7	0.01
	14	4	3	0.01	7	0.01

[0019]

[Table 4]

種 別		垂下高さ (mm)	水道水浸漬試験		水溶液浸漬試験	
			孔食数 (個)	最大孔 食 深 さ (mm)	孔食数 (個)	最大孔 食 深 さ (mm)
本発明 高強度 A1合 金管材	15	4	2	0.01	4	0.01
	16	8	3	0.01	6	0.01
	17	6	3	0.01	7	0.01
	18	5	2	0.01	4	0.01
	19	4	3	0.01	5	0.01
比 較 高強度 A1合 金管材	1	5	55	0.20	65	0.20
	2	4	34	0.20	41	0.18
	3	5	38	0.20	44	0.20
	4	4	38	0.20	47	0.19
	5	4	32	0.20	43	0.19
	6	8	40	0.20	55	0.20
	7	6	33	0.20	50	0.17
	8	5	34	0.20	52	0.20
	9	4	30	0.20	40	0.18

[0020]

[Effect of the Invention] From the result shown in Tables 1-4, this invention high intensity aluminum alloy tubing materials 1-19 With soldering heating, in Zn and a list, one or more sorts in Ga, Cd, In, Sn, Tl, and Pb carry out spreading diffusion also of any to the inside surface part (and lateral-surface section) of a tubing material, and condense them in it. Since it is in the condition that these alloy contents do not exist in the interior of a tubing material Since it has the high temperature strength of the comparison high intensity aluminum alloy tubing materials 1-9 which do not contain these alloy contents, and coincidence, and it becomes ** electrochemically by the diffusion condensation to the inside surface part in the tubing material of the above-mentioned migration component and it has become a general corrosion mold It is clear that the pitting-proof nature which was excellent much more as compared with the comparison high intensity

aluminum alloy tubing materials 1-9 which do not contain the above-mentioned minute amount alloy content is shown.

[0021] As mentioned above, the high intensity aluminum alloy tubing material of this invention Since it has high intensity, even if it carries out thinning, heat deformation is not carried out at the time of soldering. Moreover, one or more sorts in Ga, Cd, In, Sn, Tl, and Pb carry out spreading diffusion to Zn and the list which were made to contain as an alloy content as above-mentioned to the inside surface part and the lateral-surface section of a tubing material at the time of the soldering assembly of aluminum heat exchanger, and said inside surface part and the lateral-surface section are made to change to ** electrochemically. Pitting generating is lost in the inside surface part and the lateral-surface section of a tubing material by this, and, as a result, it has a useful property on industry that aluminum heat exchanger comes to demonstrate the engine performance which continued and was remarkably excellent in the long period of time etc.

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(54) 【発明の名称】 耐孔食性にすぐれたA1 熱交換器用高強度A1 合金管材

(57) 【要約】

【目的】 A1 熱交換器用高強度A1 合金管材の耐孔食性を向上させる。

【構成】 A1 熱交換器用高強度A1 合金管材を構成する、重量%で、

Fe: 0.2~1.5%、 Si: 0.05~1.2%、

を含有し、さらに必要に応じて、

Zr: 0.05~0.15%、 Mn: 0.1~1.2%、

Ti: 0.02~0.2%、 Mg: 0.05~0.3%、

のうちの1種または2種以上、

を含有し、残りがA1と不可避不純物からなる組成を有

するA1合金に、全体に占める割合で、

Zn: 0.05~0.5%と、

Ga, Cd, In, Sn, Tl, およびPbのうちの1種または2種以上: 1~100ppm、を合金成分として含有させる。

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【特許請求の範囲】

【請求項1】 重量%で、

Fe: 0.2~1.5%, Si: 0.05~1.2%

を含有し、さらに、

Zn: 0.05~0.5%と、

Ga, Cd, In, Sn, Tl, およびPbのうちの1種または2種以上: 1~100ppm、

を含有し、残りがAlと不可避不純物からなる組成を有するAl合金で構成したことを特徴とする耐孔食性にすぐれたAl熱交換器用高強度Al合金管材。

【請求項2】 重量%で、

Fe: 0.2~1.5%, Si: 0.05~1.2%

を含有し、

Zr: 0.05~0.15%, Mn: 0.1~1.2%

Ti: 0.02~0.2%、

のうちの1種または2種以上、

を含有し、さらに、

Zn: 0.05~0.5%と、

Ga, Cd, In, Sn, Tl, およびPbのうちの1種または2種以上: 1~100ppm、

を含有し、残りがAlと不可避不純物からなる組成を有するAl合金で構成したことを特徴とする耐孔食性にすぐれたAl熱交換器用高強度Al合金管材。

【請求項3】 重量%で、

Fe: 0.2~1.5%, Si: 0.05~1.2%

を含有し、

Mg: 0.05~0.3%、

を含有し、さらに、

Zn: 0.05~0.5%と、

Ga, Cd, In, Sn, Tl, およびPbのうちの1種または2種以上: 1~100ppm、

を含有し、残りがAlと不可避不純物からなる組成を有するAl合金で構成したことを特徴とする耐孔食性にすぐれたAl熱交換器用高強度Al合金管材。

【請求項4】 重量%で、

Fe: 0.2~1.5%, Si: 0.05~1.2%

を含有し、

Zr: 0.05~0.15%, Mn: 0.1~1.2%

Ti: 0.02~0.2%、

のうちの1種または2種以上と、

Mg: 0.05~0.3%、

を含有し、さらに、

Zn: 0.05~0.5%と、

Ga, Cd, In, Sn, Tl, およびPbのうちの1

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種または2種以上: 1~100ppm、

を含有し、残りがAlと不可避不純物からなる組成(以上重量%)を有するAl合金で構成したことを特徴とする耐孔食性にすぐれたAl熱交換器用高強度Al合金管材。

【発明の詳細な説明】

【0001】

【産業上の利用分野】この発明は、Al熱交換器のろう付け組立てに管材として用いた場合に、すぐれた耐孔食性を発揮する高強度Al合金管材に関するものである。

【0002】

【従来の技術】従来、例えば自動車やオートバイなどのラジエータ、さらにはエバポレータなどのAl熱交換器が、外側面にAl合金ろう材をクラッドしたAl合金管材とAl合金フィン材、あるいはAl合金管材と片面または両面にAl合金ろう材をクラッドしたAl合金フィン材とを、組立てろう付けすることにより製造され、かつ上記Al合金ろう材として、重量%で(以下%は重量%を示す)、

Si: 7~12%、

を含有し、さらに必要に応じて、

Mg: 0.1~2%, Bi: 0.02~0.2%

のうちの1種または2種、を含有し、残りがAlと不可避不純物からなる組成を有するAl合金が用いられることも知られている。

【0003】また、近年のAl熱交換器の高性能化、小型化、および軽量化に対応する目的で、薄肉化が可能な高強度を有するAl合金、例えばASTM8011に記載される通りの、

Fe: 0.6~1.0%, Si: 0.5~0.9%、

を含有し、残りがAlと不可避不純物からなる組成を有する高強度Al合金が管材として用いられていることも知られている。

【0004】

【発明が解決しようとする課題】しかし、上記の従来高強度Al合金管材においては、これを構成するAl合金が高強度、特に高温強度をもつので、薄肉化してろう付け時に熱変形することはほとんどないが、材質的に孔食が発生し易く、薄肉であることと相まって貫通孔にまで発展し、比較的短時間で使用寿命に至るという問題がある。

【0005】

【課題を解決するための手段】そこで、本発明者等は、上述のような観点から、薄肉化が可能な高強度を有すると共に、すぐれた耐孔食性を具備したAl合金管材を開発すべく、上記の従来高強度Al合金管材に着目し研究を行なった結果、上記従来高強度Al合金管材を構成するAl合金に、合金成分として少量のZnと共に、微量のGa, Cd, In, Sn, Tl, およびPbのうちの

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1種または2種以上を共存含有させると、これらの合金成分はA1熱交換器のろう付け組立て時に管材の内側面部および外側面部に拡散移動して凝集するようになり、しかもこの凝集作用はZnの存在によって一段と促進され、このように前記合金成分が凝集した管材の内側面部および外側面部は電気化学的に著しく卑になり、腐食が全面腐食型になるので孔食の発生が著しく抑制されるようになり、一方、管材の内部は、上記合金成分の内側面部および外側面部への拡散移動によって、これら合金成分がほとんど存在しない状態になっているので、管材自体は上記の従来高強度A1合金管材と同等の高強度、特にろう付け時に熱変形し難いというすぐれた高温強度を保持するという研究結果を得たのである。

【0006】この発明は、上記の研究結果にもとづいてなされたものであって、

Fe: 0.2~1.5%、 Si: 0.05~1.2%、を含有し、

Zn: 0.05~0.5%と、

Ga, Cd, In, Sn, Ti, およびPbのうちの1種または2種以上: 1~100ppm、

を含有し、さらに必要に応じて、

Zr: 0.05~0.15%、 Mn: 0.1~1.2%、

Ti: 0.02~0.2%、 Mg: 0.05~0.3%、のうちの1種または2種以上、

を含有し、残りがAlと不可避不純物からなる組成を有するAl合金で構成してなる耐孔食性にすぐれたAl熱交換器用高強度Al合金管材に特徴を有するものである。

【0007】つぎに、この発明の高強度Al合金管材において、これを構成するAl合金の組成を上記の通り限定した理由を説明する。

【0008】(a) FeおよびSi

これらの成分には、Alと結合して素地中に微細均一に分散する各種の化合物を形成し、もつて高温強度（耐熱変形性）を向上させる作用があるが、その含有量がFe: 0.2%未満であっても、Si: 0.05%未満であっても所望の高温強度を確保することができず、一方その含有量がFe: 1.5%およびSi: 1.2%をそれぞれ越えると、これら成分の素地への固溶割合が多く、この結果耐食性や加工性が低下することから、その含有量をFe: 0.2~1.5%、Si: 0.05~1.2%と定めた。

【0009】(b) Ga, Cd, In, Sn, Ti, およびPb

これらの成分には、上記の通りろう付け時に管材の内側面部および外側面部に拡散移動して凝集する性能があり、これによって管材の内側面部および外側面部は相対的に電気化学的に著しく卑となり、この結果管材の内側面部および外側面部の腐食形態が全面腐食型となること

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から、孔食の発生が皆無となる作用があるが、その含有量が1ppm未満では前記作用に所望の効果が得られず、一方その含有量が100ppmを越えると、ろう付け後に管材内部に残留するようになり、所望のすぐれた高温強度を確保するのが困難になることから、その含有量を1~100ppmと定めた。

【0010】(c) Zn

Zn成分には、上記の通りGa, Cd, In, Sn, Ti, およびPb成分の凝集を促進すると共に、自身もこれらの成分と一緒に管材の内側面部および外側面部に拡散移動して管材の耐孔食性を向上させる作用があるが、その含有量が0.05%未満では前記作用に所望の効果が得られず、一方その含有量が0.5%を越えると全面腐食が急激に進行することから、その含有量を0.05~0.5%と定めた。

【0011】(d) Zr, Mn, およびTi

これらの成分には、各種の化合物を形成して、ろう付け時に熱変形しないようにする高温強度と、室温強度をより一段と向上させる作用があるので、必要に応じて含有されるがその含有量がそれぞれZr: 0.05%未満、Mn: 0.1%未満、およびTi: 0.02%未満では前記作用に所望の向上効果が得られず、一方その含有量がそれぞれZr: 0.15%、Mn: 1.2%、およびTi: 0.2%を越えると、形成される化合物が粗大化するようになって、圧延加工性が低下することから、その含有量をZr: 0.05~0.15%、Mn: 0.1~1.2%、およびTi: 0.02~0.2%とそれぞれ定めた。

【0012】(e) Mg

Mg成分には、素地に固溶して室温強度をより一段と向上させる作用があるので、必要に応じて含有されるが、その含有量が0.05%未満では所望の室温強度向上効果が得られず、一方その含有量が0.3%を越えると、高温強度が低下することから、その含有量を0.05~0.3%と定めた。

【0013】つぎに、この発明の高強度Al合金管材を実施例により具体的に説明する。通常の溶解法によりそれぞれ表1~3に示される成分組成をもったAl合金を溶製し、以下いずれも通常の条件で、幅: 1450mm×長さ: 2800mm×厚さ: 400mmの寸法をもったスラブに鋳造し、このスラブに均質化処理を施した後、厚さ: 9mmの熱延板に熱間圧延し、ついで中間焼鈍を加えながら冷間圧延（最終冷間圧延率: 30%）を繰り返し施して厚さ: 0.2mmの冷延板とし、この冷延板から高温強度を評価する目的で、幅: 30mm×長さ: 140mmの寸法をもった耐垂下性試験用試片を切出すと共に、外面寸法で幅: 15mm×厚さ: 3mmの扁平状電線管からなる本発明高強度Al合金管材1~19、および構成成分のうちのZn並びにGa, Cd, In, Sn, Ti, およびPbを含有しない組成を有する比較高強度Al合金

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管材1~9をそれぞれ製造した。

*【表1】

【0014】

*

種 別	成 分 組 成 (重量%)													
	Fe	Si	Zr	Mn	Ti	Mg	Zn	微量合金成分 (ppm)						Al+ 不純物
								Ga	Cd	In	Sn	Tl	Pb	
1	0.22	0.74	-	-	-	-	0.26	30	-	-	-	-	-	残
2	0.83	0.60	-	-	-	-	0.33	-	60	-	-	-	-	残
3	1.47	0.53	-	-	-	-	0.46	-	-	2	-	-	-	残
4	0.94	0.053	-	-	-	-	0.16	-	-	-	8	-	3	残
5	0.41	1.18	-	-	-	-	0.05	-	25	-	-	13	-	残
6	1.16	0.64	-	-	-	-	0.20	1	-	6	-	-	4	残
7	0.54	0.83	-	-	-	-	0.26	-	20	-	15	13	-	残
8	0.86	0.96	-	-	-	-	0.13	10	11	10	10	20	5	残
9	0.84	0.64	0.05	-	-	-	0.26	1	-	-	-	-	-	残
10	0.82	0.60	-	0.63	-	-	0.23	-	50	50	-	-	-	残
11	0.80	0.62	-	-	0.06	-	0.30	20	-	-	15	15	-	残
12	0.86	0.66	0.13	0.21	-	-	0.41	-	-	-	-	80	-	残
13	0.83	0.64	0.07	-	0.03	-	0.05	-	5	-	-	-	40	残
14	0.82	0.63	-	0.16	0.15	-	0.10	-	10	20	-	7	-	残

本 発 明 高 強 度 Al 合 金 管 材

本発明高強度Al合金管材

【0015】

【表2】

種 別		成 分 組 成										(重量%)				
		Fe	Si	Zr	Mn	Ti	Mg	Zn	微量合金成分 (ppm)					Al+ 不純物		
									Ga	Cd	In	Sn	Tl		Pb	
本發明 高強度 Al合 金管材	15	0.82	0.59	0.06	0.21	0.04	-	0.24	100	-	-	-	-	-	殘	
	16	0.80	0.63	-	-	-	0.16	0.06	-	30	-	-	20	-	殘	
	17	0.79	0.62	-	0.68	-	0.19	0.09	-	-	-	-	65	-	殘	
	18	0.83	0.60	0.08	-	0.03	0.05	0.23	-	-	-	40	6	10	殘	
	19	0.81	0.61	0.11	0.74	0.07	0.03	0.49	12	13	-	18	-	20	殘	
比 較 高強度 Al合 金管材	1	0.82	0.58	-	-	-	-	-	-	-	-	-	-	-	殘	
	2	0.80	0.62	-	0.66	-	-	-	-	-	-	-	-	-	殘	
	3	0.82	0.63	-	-	0.06	-	-	-	-	-	-	-	-	殘	
	4	0.81	0.60	0.17	0.21	-	-	-	-	-	-	-	-	-	殘	
	5	0.80	0.61	0.06	0.23	0.03	-	-	-	-	-	-	-	-	殘	
	6	0.78	0.62	-	-	-	0.13	-	-	-	-	-	-	-	殘	
	7	0.79	0.61	-	0.71	-	0.17	-	-	-	-	-	-	-	殘	
	8	0.81	0.57	0.08	-	0.03	0.06	-	-	-	-	-	-	-	殘	
	9	0.83	0.59	0.11	0.73	0.09	0.03	-	-	-	-	-	-	-	殘	

【0016】なお、耐垂下性試験は、上記試片の長さ方向30mmを水平保持し、110mmの長さを水平に突き出した状態で、真空ろう付けに相当する条件、すなわち約 10^{-4} torrの真空中、温度：600℃に5分間保持の条件で行ない、試験後の試片の突出先端部の垂下高さを測定した。

【0017】また、上記の本発明高強度Al合金管材1～19および比較高強度Al合金管材1～9については、これに同じく真空ろう付けに相当する条件、すなわち約 10^{-4} torrの真空中、温度：600℃に5分間保持の条件で加熱処理を施した状態で、

(a) Cu^{2+} イオンを1ppm含有し、温度が40℃の水道水中に30日間浸漬の水道水浸漬試験、(b) Cl^- イオン：100ppm、 SO_4^{2-} イオン：100ppm、 HCO_3^- イオン：100ppm、 Cu^{2+} イオン：1ppmを含有し、温度が40℃の水溶液中に30日間浸漬の水溶液浸漬試験、を行ない、内面における40cm²当りの孔食数と最大孔食深さを測定した。これらの結果を表3、4に示した。

【0018】

【表3】

種 別		垂下高さ (mm)	水道水浸漬試験		水溶液浸漬試験	
			孔食数 (個)	最大孔 食 深 さ (mm)	孔食数 (個)	最大孔 食 深 さ (mm)
本 発 明 高 強 度 A1 合 金 管 材	1	10	2	0.02	5	0.01
	2	5	2	0.02	4	0.01
	3	5	3	0.02	7	0.01
	4	6	4	0.02	8	0.01
	5	7	4	0.02	9	0.01
	6	5	2	0.01	4	0.01
	7	6	2	0.02	4	0.01
	8	6	3	0.01	6	0.01
	9	5	2	0.02	4	0.01
	10	4	2	0.01	4	0.01
	11	5	2	0.02	5	0.01
	12	4	3	0.02	6	0.01
	13	5	3	0.02	7	0.01
	14	4	3	0.01	7	0.01

【0019】

30 【表4】

種 別		垂下高さ (mm)	水道水浸漬試験		水溶液浸漬試験	
			孔食数 (個)	最大孔 食 深 さ (mm)	孔食数 (個)	最大孔 食 深 さ (mm)
本発明 高強度 A1合 金管材	15	4	2	0.01	4	0.01
	16	8	3	0.01	6	0.01
	17	6	3	0.01	7	0.01
	18	5	2	0.01	4	0.01
	19	4	3	0.01	5	0.01
比 較 高強度 A1合 金管材	1	5	55	0.20	65	0.20
	2	4	34	0.20	41	0.18
	3	5	38	0.20	44	0.20
	4	4	38	0.20	47	0.19
	5	4	32	0.20	43	0.19
	6	8	40	0.20	55	0.20
	7	6	33	0.20	50	0.17
	8	5	34	0.20	52	0.20
	9	4	30	0.20	40	0.18

【0020】

【発明の効果】表1～4に示される結果から、本発明高強度A1合金管材1～19は、いずれもろう付け加熱によってZn、並びにGa、Cd、In、Sn、Ti、およびPbのうちの1種以上が管材の内側面部（および外側面部）に拡散移動して凝集し、管材内部にはこれらの合金成分が存在しない状態になっているので、これらの合金成分を含有しない比較高強度A1合金管材1～9と同時の高温強度を有し、かつ上記の移動成分の管材における内側面部への拡散凝集によって電気化学的に卑になり、全面腐食型になっているので、上記微量合金成分を含有しない比較高強度A1合金管材1～9に比して一段

30 とすぐれた耐孔食性を示すことが明らかである。

【0021】上述のように、この発明の高強度A1合金管材は、高強度を有するので、薄肉化してもろう付け時に熱変形することがなく、また上記の通り合金成分として含有させたZn、並びにGa、Cd、In、Sn、Ti、およびPbのうちの1種以上がA1熱交換器のろう付け組立て時に管材の内側面部および外側面部へ拡散移動して前記内側面部および外側面部を電気化学的に卑に変化せしめ、これによって管材の内側面部および外側面部に孔食発生がなくなり、この結果A1熱交換器は著しく長期に亘ってすぐれた性能を発揮するようになるなど工業上有用な特性を有するのである。